

This paper is responsive to the Notice of non-compliant amendment dated 12/16/02. The instructions to modify the specification are presented in the form required under 37 CFR 1.121(b)(1)(ii).

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In the Specification:

Please replace the paragraph beginning on page 16, line 16, with the following rewritten paragraph:

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~~★~~Figures 4a, 4b, and 4c are sections a-a, b-b, and c-c, respectively, through figure 4.~~★~~

Please replace the paragraph beginning on page 19, line 13, with the following rewritten paragraph:

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~~★~~Figure 4 shows the present invention, which provides a convergent multiple beam klystron 141 having a plurality of high current electron beams to permit construction of a multiple beam RF device of high power and high frequency.

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While the development of symmetric fields for radially symmetric devices is simplified by the intrinsic symmetry of the magnetic structures, this is not the case for multiple gun, off-axis designs such as the present invention of figure 4. As known in the art, conventional electron guns

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are designed using advanced computational tools to model the electrostatic potential, magnet flux contours, and electron

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trajectories. Examples of these codes include Maxwell 2D[®] and Beam Optics Analysis (BOA[®]) from Ansoft Corporation, the three dimensional finite difference program MAFIA[®], and the beam trajectory code XGUN[®]. These tools were used to model

5 the present invention to insure that laminar electrons beams were generated suitable for a klystron or IOT RF circuit. It is clear to one skilled in the art that magnetic field design tools of this type are required for the optimization of specific structures for use in shaping a magnetic field

10 in the present art of designing confining flow magnetic fields for use in electron beam devices. For the present invention, Maxwell 2D[®] and MAFIA[®] were used to design a magnetic configuration where lines of magnetic flux intersect each cathode perpendicular to the emitting surface

15 with sufficient magnitude to guide the electrons through the cathode-anode region into the center of each beamlet's respective beam tunnel. Maxwell 2D[®] was also used to design the electrostatic geometry providing equipotential contours consistent with the desired operation. BOA[®] and XGUN[®] were

20 used to model electron trajectories through the cathode-anode region to insure that the desired performance was achieved. *h*

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Please replace the paragraph beginning on page 20, line 23, with the following rewritten paragraph:

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--Figures 4a, 4b, and 4c show cross section views of
5 the present invention, and may be examined in conjunction
with corresponding sections a-a, b-b, and c-c of figure 4.
A plurality n of electron guns 230a, 230b,...230n is arranged
circularly around a central axis Z 150. A reference plane R
is perpendicular to the axis Z 150, and is used in the
10 illustrations for section a-a, b-b, and c-c. Figures 4a-4c
show a cross section view of a device. Each electron gun
230a..n is arranged circularly around the central axis Z and
produces a beamlet which initially focuses to a minimum
diameter 106a..n, as described earlier in figure 2. As is
15 clear to one skilled in the art, other non-circular and
irregular inter-gun spacings can be used, but the regular
spacings and circular arrangement is shown for clarity in
the drawings. Each beamlet from each electron gun 230a..n
travels through its own beam tunnel 156a..n along a beam
20 tunnel axis 152a..n to a collector 112a..n. Each beamlet
travels in its respective beam tunnel 152a..g which has a
conductive inner surface 173, and the beam tunnel comprises
drift tubes 133, 135, 137, and 139, and a series of resonant
cavities 172, 174, 176 formed by drift tube gaps, and shown
25 in figure 4-1 detail. These cavities are for the

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introduction of RF power, additional modulation of the
electron beamlets, and the extraction of RF power, as
before. The coaxial magnetic flux field generator 130
comprises a coil wound around the axis 150, which produces a
5 generally uniform flux field 132 aligned with the central
axis 150, as before. The resonators are shown as 172, 174,
176 comprise the annular ring resonators described, for
example, in U.S. Patent No. 4,508,992 by Bohlen et al (items
1 and 2), incorporated herein by reference. A key feature of
10 the embodiment shown in Fig. 4 is the presence of an iron
structure 170 and electromagnetic coil or permanent magnet
180, located along the centerline of the device and
positioned at the approximate location of the individual
cathodes 102. The iron structure 170 and magnet 180 provide
15 compensation for the radial asymmetry of the magnetic field
at the location of the individual cathodes 102, as will be
described later.--

Please replace the paragraph beginning on page 22, line 14,
20 with the following rewritten paragraph:

--Figures 4a-4c shows the sections a-a, b-b, and c-c,
respectively, which include beam tunnels 156a..n, and the
inner surface 173 and outer surface 171 of resonators 174.--

Please replace the paragraph beginning on page 23, line 19, with the following rewritten paragraph:

5 --An embodiment of the magnetic circuit for the device
of Fig. 4 is shown in Fig. 6a. A shell of magnetic iron 140
encloses magnetic coils 130 that generate the main magnetic
field for the RF device. As is clear to one skilled in the
art, it would be possible to substitute a self-magnetic
10 structure such as a permanent magnet for the coil 130 with
appropriate modifications to iron structure 140. Apertures
210 are placed in the end walls of the shell 140 to allow
passage of the electron beamlets and to allow magnetic flux
to extend into the cathode-anode regions 101 (not shown) of
15 the electron guns to aid in beam focusing. An auxiliary
electromagnet coil or permanent magnet 180 is located along
the device centerline 220 and between the centerline and the
individual electron guns 230. In addition magnetic material
170 is located along the device centerline 220 and between
20 the electron guns 230 and the centerline 220. The magnetic
iron 170 may include semicircular extensions 178 extending
partially around the centerline of each individual beamlet
217 to reduce azimuthal asymmetries in the magnetic field at
the location of the individual cathodes 102.--

Please replace the paragraph beginning on page 24, line 16, with the following rewritten paragraph:

--Figure 6b shows a section in the RZ coordinate system in the region between the magnetic polepiece end plate 140 and the electron gun emitter 102 where no correction is made to the magnetic field using coil 180 (not shown) or magnetic structure 170 (not shown). The figure plots contours of constant magnetic field 342 emanating through aperture 210 and extending to cathode 102. Certain structures from figure 6b are shown on figure 6c for clarity, including electron gun cathode 102 with electron emitting surface 101, shell 140, and beam tunnel axis 152. Note the asymmetry about the cathode centerline 152 and the variation of magnetic field across the emitting surface 101 of the cathode 102. Electrons emitted perpendicular to surface 101 will experience a magnetic field in which the direction of the magnetic field vector is different from the direction of electron motion, thereby imparting a transverse force on the electron that will prevent proper transmission through the RF device.--

Please replace the paragraph beginning on page 25, line 17, with the following rewritten paragraph:

5 --An alternate embodiment is shown in figure 7, where
an additional field shaping electromagnet coil 232 is
located about the centerline of the device 220 but at a
distance from the centerline so as to surround the cathodes
for the individual beamlets. Certain structures from figure
6a are shown in figure 7 for clarity including Auxiliary
10 coil 180, shell 140, coil 130, apertures 210, beamlets 217,
iron structure 170, main magnetic field 132, and cutout 178.
As is clear to one skilled in the art, and shown in figure
8, permanent magnets 240 and 242 could be substituted for
coils 232 and 180 of figure 7 with no change in function.
15 Field shaping electromagnet 232, or 180 or shaping magnet
240 or 242 would equivalently allow additional control of
the magnetic field in the region of the electron beamlets.
An alternate embodiment would include an iron shield
partially enclosing coil 232 on the outer circumference and
20 end to limit flux leakage into the environment and reduce
the power required for electromagnetic coils or the field
strength for permanent magnets. Certain structures from
figure 6a are shown in figure 8 for clarity including shell
140, coil 130, apertures 210, beamlets 217, main magnetic
25 field 132, iron structure 170, central axis 220, and cutout
178. As is clear to one skilled in the art, there are many

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combinations of electromagnets or permanent magnets which could be used to satisfy the condition of creating a magnetic field which is perpendicular in gradient to the electron beam trajectory over all operating regions of the device. ~~6~~

Please replace the paragraph beginning on page 26, line 14, with the following rewritten paragraph:

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10 ~~6~~Figure 9 shows the device of figure 4 wherein the iron 140 and magnetic coils 131 are replaced by iron 250, 251, and permanent magnet 254, respectively. Certain structures from figure 4 are shown in figure 9 for clarity including electron guns 230a and 230e; beamlet focusing to
15 minimum diameter 106a and 106e, central axis 150, iron structure 170, thermionic emitting surface 102a and 102e, resonators 172, 174, and 176, cathode centerline 152a and 152e; electron collector 112a and 112e; inner surface 173; and outer surface 171. ~~7~~

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Please replace the paragraph beginning on page 26, line 17, with the following rewritten paragraph:

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C 25 ~~7~~Figure 10 shows an alternate embodiment of the multiple beam device where additional magnetic material 260 is incorporated at a larger radius than the electron guns
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